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THESIS

COST AND SCHEDULE GROWTH DURING WEAPON SYSTEM ACQUISITION: AN INVESTIGATION OF THE IMPACT OF SELECTED ECONOMIC AND POLITICAL FACTORS

by

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December 1990

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2. The creation of measures of cost and schedule growth.
3. Statistical analysis was conducted to test the hypothesized relationships between program outcomes and explanatory factors.

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General conclusions from this study are that significant relationships do exist between cost and schedule growth and specific political and economic explanatory factors.

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Cost and Schedule Growth During Weapon System Acquisition: An Investigation of the Impact of Selected Economic and Political Factors

by

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ABSTRACT

The primary objective of this study is to document relationships between two weapon system program outcomes, cost and schedule growth, and aspects of the political and economic climate during system development. The data sample selected for study was aerospace industry-related weapon system programs. The central methodology used in the analysis included:

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TABLE OF CONTENTS

I. INTRODUCTION

A. BACKGROUND

The Department of Defense is charged with the broad requirement of ensuring the national security. We live, however, in a period of great insecurity. As the recent invasion of Kuwait by Iraq serves to illustrate, the change in the roles of the world's superpowers has done nothing to reduce the need for a sophisticated, flexible military capability.

Yet, such a capability has proven to be incredibly expensive, in terms of both national resources and time. At the same time, the amount of resources available to the Department of Defense have been reduced, and may be expected to continue to decline for the foreseeable future.

It is this environment that today's--and the future's--program managers, budgeters, and policy makers must work within as they grapple with the means to reduce the cost and time required to procure the Department of Defense's "tools of the trade": weapon systems.

This study will look at cost and schedule growth for a representative sample of weapons from the aerospace industry. Some non-technical but potentially important factors that may influence cost and schedule growth will be introduced, and the nature of their relationships with cost and schedule growth will be hypothesized and examined. Specifically, this study will examine the relationships of cost and schedule growth with selected economic, political/budgetary, and weapon system program-related factors.

There have been several related studies done. One such study, by K.W. Tyson, J.R. Nelson, N.I. Om, and P.R. Palmer, Acquisition of Major Systems: Cost and Schedule Trends and Acquisition Initiative Effectiveness [Ref. 1], provides the background for this study. In their study, Tyson, et al., created a sample containing cost and schedule growth data for a large set of weapon systems produced since the 1960's, and provided measures of program outcomes vis-a-vis cost and schedule growth. A central purpose of the Tyson, et al., study was to provide a description of program outcomes. Associations between program outcomes and certain contracting initiatives were also examined.

This study goes beyond the description of program outcomes, to explanation: why was cost and/or schedule growth relatively high or low on some programs when compared with others? What factors seem to explain or influence this growth? These are some of the questions this study attempts to answer.

In the remainder of this chapter, the objectives of this study are developed. The methodology is then described, followed by a summary of the study's findings. Finally, an outline of the contents of the following chapters is provided.

B. THESIS OBJECTIVE

The objective of this study is to document relationships between weapon system acquisition program outcomes, and aspects of the political and economic climate during the period of system development. It will also address whether these relationships are systematic, predictable, and significant. The desired benefit of this analysis is to create at least a preliminary understanding of the nature of these relationships.

C. METHODOLOGY

To achieve this objective, the following methodology was adopted:

- Relevant literature discussing factors that influence cost and schedule performance during weapon system procurement was reviewed;
- Factors reflecting the economic and political conditions that are expected to be associated with program outcomes were identified;
- The nature of the expected relationships were specified as hypotheses;
- Operational measures of cost growth and schedule growth were created. The Tyson data base and procedures were used in this step;
- Data were collected and measures created to operationalize the relevant economic/political factors;
- Statistical analysis was conducted to test the hypothesized relationships between program outcomes and

explanatory factors. The analysis was conducted to separately explain three program outcomes:

* development cost growth,
* development schedule growth,
* total program cost growth;

- Conclusions concerning the significance and importance of economic/political factors in explaining program outcomes were provided.

D. SUMMARY OF FINDINGS

This study was able to document that some significant relationships do exist between program outcomes and economic and political explanatory factors. Primarily, two preliminary conclusions were reached. First, cost growth is more sensitive to the explanatory factors than schedule growth. This is reasonable in that weapon system program control is exercised through budgetary means. Second, Congressional Majority Party has a significant impact on cost and schedule growth. Specifically, cost and schedule growth is greater for programs initiated when there is a relatively stronger democratic majority in Congress.

E. THESIS OUTLINE

In Chapter II the explanatory factors are discussed, and hypotheses presented. The results of a literature review attempting to identify possible explanatory factors is recounted. Eight explanatory factors are identified and separated into three broad categories: Economic Factors, Political/Budgetary Factors, and Program Related Factors. A scenario explaining how each of these factors might logically impact program cost and/or schedule growth is developed, followed by a statement of specific hypotheses.

Chapter III presents the sample constructed by Tyson, et al., the methods used to measure the explanatory factors identified in Chapter II (the independent variables), and the procedures used to construct the measures for the program outcomes (the dependent variables).

In Chapter IV, the results of the analysis testing the hypotheses are presented. The tests used to conduct the analysis are described, and the findings tabulated and discussed.

In Chapter V, the work described in Chapters II, III, and IV is summarized, and conclusions are drawn from the results of analysis. Limitations and constraints on the conduct of the study are then discussed, followed by some recommendations for further research.

II. DISCUSSION OF EXPLANATORY FACTORS AND STATEMENT OF HYPOTHESES

As stated in Chapter I, the objective of this study is to identify factors that could be expected to influence program outcomes (cost and schedule growth) and to test for associations between program outcomes and these factors. The purpose of this chapter is to identify and discuss the explanatory factors that will later be investigated empirically in the study.

The approach used to identify potential factors of interest was to review related literature that investigated similar problems. Two studies were particularly helpful in this respect. Tyson, et. al. [Ref. 1] explicitly studied cost and schedule growth of weapon system programs. In fact the measures of cost and schedule outcomes used in the current analysis are from the earlier Tyson et. al., study. The current study will examine some cost/schedule growth factors suggested and previously tested by Tyson et al. Moses [Ref. 4] also explicitly investigated cost over and underruns. A list of explanatory factors offered by Moses was relied upon to identify factors relevant to the current analysis. Two other works also proved helpful; White and Hendrix [Ref. 3] and Moses [Ref. 2]. White and Hendrix reviewed the broad process of defense acquisitions and, at points, suggested possible factors that may influence cost/schedule outcomes. Moses conducted a study of contractor pricing strategies, and in so doing suggested factors that may influence costs paid during acquisition.

There are many reasons for cost/schedule growth suggested in the literature. The factors investigated in this study represent only a subset, and the list does not pretend to be exhaustive. Four criteria were considered in selecting factors for analysis: 1) The factor was suggested in the literature as having a potential impact on cost or schedule performance during the acquisition of weapon systems; 2) The manner in which a factor would be expected to influence cost/schedule outcomes could be stated, i.e., an unambiguous hypothesis could be developed; 3) Procedures for creating reasonable measures of the factors could be envisioned; 4) Data were available to create the measures.

The factors to be addressed empirically in the study fall into three broad categories. The category boundaries are somewhat fuzzy, but the category labels provide some general indication of the kinds of factors identified in the literature review.

- Economic Factors;
  * Economy Wide Conditions,
  * Industry Capacity Utilization.
- Political/Budgetary Factors;
  * Defense Spending,
  * Acquisition Environment,

* Presidential Party,
* Congressional Party.

- Program-Related Factors;
  * Program Type (New versus Modified),
  * Program Stretch Out.

Consider the concept of cost (or schedule) growth: Any indicator of cost growth involves a comparison of two measures of cost, an initial estimate and an after-the-fact actual cost. "Cost growth" may result from one or both of two mechanisms. First, the initial estimate may be too "low." Thus even if actual cost incurrance is "normal," cost growth will appear to occur. Second, the initial estimate may be "fair." But actual cost performance may be inefficient. Again, cost growth will be apparent.

The current study focuses on the first of these two mechanisms. Attention will be directed toward factors that may cause initial estimates of cost or schedule to be biased (downward). Thus in general, each of the above factors is an attempt to reflect some aspect of the economic, political, or budgetary environment existing at the initiation of a weapon system program (or some aspect of the program itself) which is anticipated to have an effect on initial estimates of cost and/or schedules. Thus each factor is expected to provide some opportunity, some incentive, or some constraint which could lead to an impact on program cost or schedule.

The remainder of the chapter discusses each factor individually. For each factor, the discussion covers the following: a) a description of the factor; b) an argument supporting the hypothesis that the factor may be associated with cost and/or schedule outcomes (this usually takes the form of a story or scenario by which the factor leads to government or contractor actions that impact costs or schedule); c) an indication of the results of relevant prior research; d) an indication, when necessary, of how the factor will be operationalized (measured) empirically; and e) an explicit statement of the hypothesis stating the anticipated relationship between the factor and cost/schedule outcomes.

A. ECONOMIC FACTORS

1. Economy-wide Conditions

This factor may be described simply as the state of the U.S. economy, i.e., growth, stagnation, or contraction.

If economic conditions are poor (stagnant or contracting) during the period in which initial planning and negotiations for a project occur, demand from the commercial product market may be correspondingly reduced. Capital intensive firms may desire additional work to keep their equipment and personnel occupied. This may cause these firms to look for additional work in defense contracts, which may be in relatively large supply compared to the demand for commercial products. If many firms pursue government defense work in this way, there may be sufficient competition among them to cause a reduction in price and/or schedule estimates, as firms will reduce these estimates in their offers in an attempt to improve their chances of obtaining the contract(s). These estimates may leave insufficient slack to deal with future contingencies without increasing costs and/or schedule delays.

- H_1: Poor economic conditions at the time of program initiation are expected to be associated with subsequent cost and/or schedule growth.

The rate of growth (or contraction) in the Gross National Product (GNP) will be used to measure the economy's condition.

2. <u>Industry Capacity Utilization</u>

This factor refers to what amount of manufacturing capacity of the defense industry is in use at a given point in time.

The amount of excess capacity the industry possesses will determine how much additional work the industry can accommodate. If industry wide capacity utilization in the period prior to contract award is low, firms desiring new or additional defense contracts will be in competition with other firms in the defense industry, and will be likely to respond to the competition by lowering their bid price in order to obtain a contract. In the process of reducing prices to win contracts, they may underestimate the true cost and schedule requirements, and cost or schedule overruns may be experienced as a result.

Greer and Liao [Ref. 5] found that when industry capacity is low, defense firms in the aerospace industry are more likely to lower their prices to attain defense contracts. Also, the inverse was found to be true: when capacity utilization is high, firms are essentially "too busy" to bid aggressively for defense work, and prices stay higher.

- H_2: Low industry capacity utilization at the time of program initiation is expected to be associated with subsequent cost and schedule growth.

B. POLITICAL/BUDGETARY FACTORS

1. Defense Spending

The level of defense spending surrounding the period of contract award may influence cost and schedule outcomes. Consider the level of defense spending immediately prior to contract award, when estimates of program costs are being made. If spending on defense has been relatively tight in the period leading up to contract award, contractors may perceive the need to bid low to obtain a contract, due to apparent constraints on the government's willingness to support defense spending. DoD cost estimators and negotiators may "accept" low estimates, to get a program started. Thus cost and schedule estimates may understate the actual higher level of costs and time required to successfully complete the contract. This would cause increased cost and/or schedule growth through the life of the program.

- H_3: Low levels of defense spending at the time of program initiation is expected to be associated with subsequent cost and/or schedule growth.

2. Acquisition Environment

The defense acquisition process has been in a state of almost continual evolution since World War II, with a rapid increase in the rate of change beginning in the early 1960's. For purposes of this study, the acquisition environment refers to the volume of legislative regulation related to the process.

Over the years, Congress has enacted successive pieces of legislation in the hope of reducing defense program acquisition costs and controlling defense contractor performance. Few if any laws applicable to this process have been repealed. If this process has had the desired effect, we would expect to see defense contractor performance with respect to cost and schedule outcomes improve over time. That is, new and better regulations controlling contractor behavior and the government's role in the acquisition process may directly lead to reductions in cost and schedule growth.

It is possible, however, that these successive reforms may have had an effect other than that desired. The increases in the legislation and regulations designed to improve the overall process may have in fact substantially increased the cost of compliance for contractors. Costs and schedules could be expected to grow with the increased scrutiny and paperwork contractors must endure and create as they struggle to comply.

The volume of acquisition regulation is directly related to the passage of time. The later a program was started, the more regulations that exist pertaining to it, and the less effectively it may be managed. It may consequently cost more and take longer to produce.

- H_4: Programs initiated more recently are expected to be associated with higher cost and schedule growth.

3. Presidential Party

This factor simply refers to the political party of the President of the United States at the time of program initiation. The president of the United States is in a powerful position of leadership, thereby deriving a significant level of legislative influence. A cursory look at the last 40 years or so would provide grounds to argue that presidents have used this influence to affect the government's position regarding defense policy in general, and towards the defense industry in particular.

The Republican party has traditionally been perceived as the advocate of big business and defense interests. It is possible that Republican presidents have used their influence to pursue defense spending as well as to promote other "pro defense" policies. If the traditional view of Republicans is correct, Republican administrations can be expected to take actions which will facilitate the initiation of defense programs. A downward biasing of initial cost/schedule estimates, or the willingness to accept uncritically such favorable estimates, would have this effect. Thus, we would expect to see higher cost and schedule growth in programs initiated when there is a Republican rather than a Democrat in the White House.

- H_5: Programs initiated under a Republican presidential administration are expected to be associated with subsequent cost and/or schedule growth.

4. Congressional Majority Party

This factor describes the situation of political party control in the legislative branch of the United States government, specifically the House and Senate of the Congress.

The majority party in Congress as a whole should be able to exercise controlling influence with regard to defense spending. In addition to possessing the larger voting block, organizational rules within the Congress stipulate that all standing committee chairpersons be members of the majority party. Thus, the majority should be able to defend a same-party president's budgetary desires, and undermine or counter those of the other party's president. Given incentives analogous to those discussed above in the case of the president's political party, we might expect to see greater cost and schedule growth for programs initiated when Republicans hold a relatively larger representation in Congress.

- H_6: Programs initiated when Republicans have relatively stronger representation in Congress are expected to be associated with subsequent cost and/or schedule growth.

C. PROGRAM-RELATED FACTORS

1. Program Type (New versus Modified)

"New" programs are those that are the first to possess their given designation, e.g., AV-8A. Modified systems are those that are improvements to the original "new" system, e.g., AV-8B.

New systems are initiated in response to a change in the perceived threat that cannot be met through an existing system. Thus, they are usually designed "from scratch" and require significant research and development, and frequent fine tuning during actual production. In contrast, modified systems are generally incremental changes that leave the majority of the original, proven system unchanged, and thus benefit greatly from not having to start completely over.

Testing requirements should be shorter, and cost and schedule requirements should be easier to predict and control.

- H_7: New programs are expected to be associated with greater subsequent cost and schedule growth.

Tyson, et al., found that the expected relationship between lower cost and schedule growth and modification programs held, except in the cases of electronic warfare aircraft and air-launched tactical munitions.

2. <u>Program Stretch Out</u>

Program stretch out refers to the condition whereby the government alters plans to procure a set number of a system by obtaining fewer each year, but for more years.

> The service...starts off assuming that a certain number of dollars will be available with which to procure certain quantities of various weapon systems. Then, typically, the Total Obligational Authority is reduced--often by the president first, then by Congress. The proper way to handle such a budget cut, in order to maintain the efficiency of the remaining programs, would be to assign priorities and then to defer or cancel enough lower priority programs that the cuts could be absorbed. Historically, both the DoD and Congress have been reluctant to cancel programs; the approach has been simply to buy fewer units of each system "this year" and to stretch out *all* the programs, hoping to purchase the rest of the units in later years. [Ref. 6:pp. 122-123]

In this way, we see the decision to stretch out programs will by definition increase their schedule growth. And, as fewer units are produced each year, their per unit costs should also grow. Fewer units are purchased at greater cost over a longer than planned period of time.

- H_8: Program Stretch Out is expected to be associated with cost and schedule growth.

Tyson, et al. [Ref. 1] investigated the role of program stretch out in cost and schedule growth. Their research clearly demonstrated the relationship between the deliberate lengthening of a program in the development and production phases with cost and schedule growth.

D. SUMMARY

In this chapter, the explanatory factors to be investigated were identified and discussed. Through a review of the literature, eight separate factors were identified. An explanation of how these factors may impact cost and/or schedule growth was developed, and the hypotheses that will later be tested were presented.

In Chapter III, the context in which the hypotheses are to be tested will be discussed. Specifically, Chapter III describes the sample of programs to be studied, the methods for operationalizing each of the explanatory factors, and the methods for measuring the dependant variables.

III. SAMPLE/DATA/MEASURES

This chapter describes the sample to be used for the analysis, the methods used to operationalize the explanatory factors presented in Chapter II as independent variables, and the procedures used to construct the outcome measures, i.e., the dependent variables reflecting cost and schedule growth. In presenting the sample, the data gathering process used by Tyson, et al. [Ref. 1] will be briefly described. The entire data base is included in the Appendix.

The measures of cost and schedule growth were taken from Tyson, et al.'s previous analysis of the 89 systems in the sample. These cost and schedule growth measures are the dependent variables for this study.

In operationalizing the explanatory factors from Chapter II, the method of measurement will be presented and discussed, along with an argument, where necessary, of how the measure captures the essence of the explanatory factor.

A. THE ACQUISITION PROGRAM SAMPLE

The sample used in the current study was originally compiled by Tyson, et al. [Ref. 1]. In the Tyson study, 89 separate weapon system acquisition programs, listed in

Table III-1, were investigated. The 89 systems fell within the following equipment types:

- Tactical Aircraft;
- Electronic Aircraft;
- Helicopters;
- Other Aircraft;
- Air-Launched Tactical Munitions;
- Surface-Launched Tactical Munitions;
- Electronics/Avionics;
- Strategic Missiles;
- Satellites.

Chronologically, the sample spans a 32 year period, from 1958 to 1985, and includes Army, Navy (including Marine Corps), and Air Force programs. The primary source of cost and schedule information were Selected Acquisition Reports (SAR). Other sources were the Defense Market Service "Missiles Market Intelligence Reports" and Jane's Weapon Systems 1987-88. The sample includes both programs that were considered to be successful as well as some that were considered to have had encountered problems, in development and/or production. Nearly all programs in the sample are either still in production and in service, or are previous versions of weapon systems that are still in production or service.

TABLE III-1

WEAPON SYSTEM PROGRAMS

Tactical Aircraft	Electronic Aircraft	Helicopter	Other Aircraft	Air-Launched Tactical Munitions
F-14A	E-3A	UH-60A	C-5A	AIM-7E*
F-14D*	E-4	AH-64A	C-5B*	AIM-7F*
F-15	EF-111A*	OH-58D*	FB-111A*	AIM-7M*
F-16	S-3A	CH-47D*	V-22	AIM-9L*
F/A-18	E-2C*	Cheyenne	C-17A	AIM-9M*
A-10	E-6A	LAMPS MK III	B-1A	AIM-54A
F-5E*	EA-6B*		B-1B*	AIM-54C*
AV-8A	P-3C*		T45TS*	HARM
AV-8B*				Harpoon
				AGM-65A/B
				AGM-65D/G*
				AMRAAM
				Hellfire
				TOW
				TOW2*
				Condor

Surface Launched Tactical Munitions	Electronics/ Avionics	Strategic Missiles	Satellites
MLRS	ASPJ	ALCM	DMSP
CLGP	JSTARS	Tomahawk*	NAVSTAR GPS
5 Inch GP	JTIDS	Trident II*	DSP
STD Missile 2*	LANTIRN	GLCM*	DSCS III
Patriot	MLS	Small Missle (ICBM)	
Pershing II*	OTH-B	Minuteman II*	
Lance	TRI-TAC	Minuteman III*	
Roland*	WIS	Peacekeeper	
Sgt York	ADDS	SRAM	
Improved Hawk*	SINCGARS	SRAM II*	
Dragon			
Shillelagh			
MK-48			
MK-48 ADCAP*			
MK-50			
Stinger--Basic			
Stinger--Post*			
Stinger--RMP*			

* Denotes modified vice new programs.

B. PROGRAM OUTCOMES/DEPENDENT VARIABLES

In this section, the methods for constructing the three dependent variables will be described.

These variables were constructed by Tyson, et al., as outcome measures in their study. Tyson, et al., found that there were significantly different drivers for cost and schedule growth in the development phase of a program's life when compared to the production phase. Thus, separate measures of cost and schedule growth for both development and production phases were created, so that each could be evaluated independently. Total cost growth was also included to provide an overall measure of cost growth for each program.

The current study will address the following three outcome measures as dependent variables:

- Development Cost Growth;
- Development Schedule Growth;
- Total Program Cost Growth.

Each variable is measured as a ratio of an initial estimate (of cost or schedule) with an actual outcome (or a most recently updated "current" estimate). See Table III-2 for summaries of the program outcomes, and the labels that will be used for them in later chapters of this study.

1. Development Cost Growth

The measure of development cost growth was constructed by dividing the estimate of total development

TABLE III-2

DEPENDENT VARIABLES

Dependant Variables	Concept	Label
Development Cost Growth	Ratio of the estimate of Total Cost at IOC Date to Initial SAR Development Cost Estimate	DCG
Development Schedule Growth	Ratio of Actual Time, FSD to IOC, to Estimated Time, FSD to IOC	DSG
Total Program Cost Growth	Ratio of Program Cost to Program Cost Estimate	TPCG

cost as of the initial operational capability (IOC) date by the initial development cost estimate provided in the initial SAR for the program. Thus,

$$DCG = \frac{\text{Development Cost as of IOC Date}}{\text{Initial SAR Development Cost Estimate}}$$

Development costs incurred after IOC were not included, as these were for major system modifications, and considered beyond the scope of the original development effort [Ref. 1:p. III-7].

2. Development Schedule Growth

Tyson, et al., measured schedule growth during development by measuring the time between full scale development commencement and its completion. The development schedule growth (DSG) ratio was then computed using the following formula:

$$DSG = \frac{\text{Actual Time (Months) From FSD to IOC}}{\text{Estimated Time (Months) From FSD to IOC}}$$

3. Total Program Cost Growth

Estimates of total program costs (TPC) were determined by adding the estimate of development costs from the SAR at the initial operational capability (IOC) date to the production cost estimate (CE) for the quantity originally ordered (called the development estimate quantity, or DEQ):

$$= \frac{\text{Development Costs Estimate @ IOC + CE for DEQ}}{\text{Total Program Cost (TPC)}}$$

The total program cost growth (TPCG) ratio was then derived by dividing total program cost by the estimate of total program cost, determined at Milestone II (just prior to the initiation of full scale development).

$$TPCG = \frac{\text{Total Program Cost (TPC)}}{\text{Total Cost Estimate, Milestone II}}$$

C. EXPLANATORY FACTORS/INDEPENDENT VARIABLES

In this section, the methods for measuring each of the factors identified in Chapter II will be presented. Where necessary, justification for the method used will be provided.

The factors included in this study require data measured at the beginning of the program. Tyson, et al., defined the program's beginning as the approval date for full scale development. Data measured at a program's beginning are taken for the year in which full scale development began. Full scale development dates are provided in Tyson, et al.'s work[1]. See Table III-3 for a summary of the explanatory factor variables, their labels and hypothesized relationships. The Appendix provides a complete list of the programs and values for all their variables.

TABLE III-3

INDEPENDENT VARIABLES

Independent Variables	Concept	Label	Hypothesized Relationship
Economy Wide Conditions	Change in GNP for Year Prior to FSD	ECON	(-)
Industry Capacity Utilization	Industry Capacity Utilization Rate at FSD Date	CAPUTIL	(-)
Change in Industry Capacity Utilization	Change in Industry Capacity Utilization for Year Prior to FSD	D-CAPUTIL	(-)

[1]Labeled "ACQ ENV" in the Appendix of this study.

1. Economic Factors

a. Economy Wide Conditions

Hypothesis One requires a measure of growth (or decline) in the Gross National Product (GNP). For each program, the change in the growth in GNP for the year prior to the year of program full scale development initiation was calculated. This reflects the trend in the economy at the time full scale development was initiated. The figures for GNP are in constant 1982 dollars.

- ECON: Change in GNP for the year prior to FSD.

GNP data for each program's FSD year were taken from H.W. Stanley and R.G. Niemi [Ref. 9:pp. 346-347].

b. Industry Capacity Utilization

Hypothesis Two requires a measure of an industry-specific economic condition, industry capacity utilization. For each program, two measures were constructed: a measure of the percentage of industry capacity utilization at the time of program initiation (i.e., FSD), and a measure of the change in industry capacity utilization during the year immediately prior to FSD. The first measure reflects the degree of capacity utilization; the second measure reflects the recent trend.

- CAPUTIL: Industry capacity utilization at FSD date.
- D-CAPUTIL: Change in industry capacity utilization for the year prior to program FSD.

Data to measure these variables were taken from Greer and Liao [Ref. 5]. For all programs, aerospace industry capacity utilization was used. This is argued to be acceptable because each program in the sample either flies, fires an aerodynamic projectile, is a space system, or a communication system for one of the above[2].

2. <u>Political/Budgetary Factors</u>

a. Defense Spending

Hypothesis Three requires a measure of the defense spending level for the year each program began full scale development. For each program, two measures were constructed: a measure of total defense outlays at the time of program initiation (FSD), and a measure of the change in defense spending during the year immediately prior to FSD. The first measure reflects the impact of defense spending, the second measure reflects the recent trend.

- DEFSPND: Outlays for defense for the year of program FSD start.
- D-DEFSPND: Change in outlays for defense for the year prior to program FSD.

The level of defense spending for the year prior to the program's beginning was found in the OMB Historical

[2]The exceptions within this list are the three torpedoes (MK-48, MK-48 ADCAP, and MK-50). Their producers, Honeywell, Gould, and Hughes, are sufficiently involved in aerospace-related programs to warrant their inclusion in this list.

Tables of the Budget of the United States Government [Ref. 7]. All amounts are in billions of constant 1982 dollars.

b. Acquisition Environment

Hypothesis Four requires some measure of the effect of the passage of time and the consequential addition of new acquisition legislation. One measure for each program was constructed, consisting of the last two digits of the year each program entered FSD. This measure reflects the impact of the acquisition environment, based on the point in time at which programs were exposed to it.

- ACQ ENV: Year program entered FSD.

These variables were taken from Appendix A of Tyson et al.'s study [Ref. 1].

c. Presidential Party

Hypothesis Five requires a measure of major political party (Republican or Democrat only) occupation of the Presidency at the time each program began FSD. For each program, one measure was constructed. A "0" was assigned if the president at FSD start year was a Democrat, and a "1" assigned if a Republican.

The measure will thus quantitatively reflect the presidential political party at the beginning of FSD for each program.

- PRES PARTY: Presence of a Democrat or Republican in the office of President of the United States at program FSD start.

Data for these measures were taken from H.W. Stanley and R.G. Niemi [Ref. 9].

d. Congressional Majority Party

Hypothesis Six requires a measure of the relative degree of political power between parties in the U.S. Congress. For each program, six separate measures were constructed. The first three measure the ratio of Democrats to Republicans in the House, the Senate, and combined (i.e., the Combined Houses of Congress). That is, the total number of Democrats divided by the total number of Republicans in the House, Senate, and Combined Houses for the year of program FSD start. The second three measure the change in the ratio of Democrats to Republicans in the House, Senate, and combined, for the year prior to program FSD. The first three measures reflect the party majority; the second three measures reflect the recent trend in that majority.

- HSE RATIO: The ratio of Democrats to Republicans in the House of Representatives at program FSD start.
- SEN RATIO: The ratio of Democrats to Republicans in the Senate at program FSD start.
- CONG RATIO: The ratio of Democrats to Republicans in the Combined Houses at program FSD start.
- D-HSE RATIO: The change in the ratio of Democrats to Republicans in the House of Representatives for the year prior to program FSD start.
- D-SEN RATIO: The change in the ratio of Democrats to Republicans in the Senate for the year prior to program FSD start.

TABLE III-4

INDEPENDENT VARIABLES

Independent Variables	Concept	Label	Hypothesized Relationship
Defense Spending	Outlays for Defense for Year of Program SD Start	DEFSPND	(-)
D-Defense Spending	Change in Outlays for Defense for the Year Prior to Program FSD Start	D-DEFSPND	(-)
Acquisition Environment	Year Program Began FSD	ACQ ENV	(+)
Presidential Party	Party of President in Program FSD Start Year	PRES PARTY	(+)
Congressional Majority Party:			
House Ratio	Ratio of Democrats to Replicans in the House in FSD Start Year	HSE RATIO	(-)
Senate Ratio	Ratio of Democrats to Replicans in the Senate in FSD Start Year	SEN RATIO	(-)
Congressional Ratio	Ratio of Democrats to Replicans in the Combined Houses in FSD Start Year	CONG RATIO	(-)

TABLE III-4 (CONTINUED)

Independent Variables	Concept	Label	Hypothesized Relationship
Change in House Ratio	Change in Ratio of Democrats to Republicans in the House in FSD Start Year	D-HSE RATIO	(-)
Change in Senate Ratio	Change in Ratio of Democrats to Republicans in the Senate in FSD Start Year	D-SEN RATIO	(-)
Change in Congressional Ratio	Change in Ratio of Democrats to Republicans in the Combined Houses in FSD Start Year	D-CONG RATIO	(-)

- D-CONG RATIO: The change in the ratio of Democrats to Republicans in the Combined Houses for the year prior to program FSD start.

Data to measure these variables were taken from the U.S. Government Organization Manual, 1960-1989. [Ref. 8]. As constructed, these ratios are larger when there are more Democrats than Republicans in the respective unit measured i.e., the House, Senate, or Combined Houses.

3. Program-Related Factors

a. Program Type (New Versus Modified)

Hypothesis Seven requires a measure of the difference between .ew and modified programs. For each program, one measure was constructed: a "0" was assigned to programs that were new programs, and a "1" assigned to programs that were modifications to existing programs. This measure will quantify the difference between new and modified programs at their FSD start.

- PRO TYPE: Designation as a new or modified program.

These measures were taken from Appendix A of Tyson, et al.'s study [Ref. 1]. Table III-1 of this study identifies the modified programs with an asterisk.

b. Program Stretch Out

Hypothesis Eight requires a measure of how much a program schedule grows from program start to completion, while at the same time controlling for schedule increases that are due to an increase in the quantity planned. For each program, one measure was constructed by Tyson, et al. They determined production schedule growth for the life of the program, and divided it by product quantity growth for the same period.

$$\text{Program Stretch Out} = \frac{\text{Production Schedule Growth}}{\text{Product Quantity Growth}}$$

This ratio reflects the magnitude of program stretch out for each program. These variables were taken from Appendix A of Tyson, et al.'s study [Ref. 1].

Note the similarity between Program Stretch Out and DSG. They differ in that the Program Stretch Out variable controls for the effect of changes in quantity over the development/production period, where DSG is a measure of the total elapsed time for full scale development.

- PROG S/O: The ratio of production schedule growth to production quantity growth.

It should also be noted that Tyson, et al.'s construction of the Program Stretch Out variable does not explicitly include changes in the development schedule as part of the measure. Program Stretch Out is nonetheless argued to be acceptable in the current study for two reasons: first, many programs have substantial overlap and compression between the development and production phases. The B-1B, V-22, and B-2 programs are most recent examples. Second, Tyson, et al., state that Program stretch Out is a significant determinant in total program cost growth, a program outcome examined in this study [Ref. 1:p. V-2].

As an example of Program Stretch Out, a normal value, indicating no stretch, would be 1.0. A value of 2.0 would indicate that the schedule doubled while producing the same quantity.

TABLE III-5

INDEPENDENT VARIABLES

Independent Variables	Concept	Label	Hypothesized Relationship
Program Type (New vs Modified)	Designation as a new or modified Program	PRO TYPE	(-)
Program Stretch Out	The Ratio of Production Schedule Growth to Product Quantity Growth for the Same Period	PROG S/O	(+)

In this chapter, sample programs were presented, listed by weapon system type. The dependent variables were presented, and Tyson et al.'s methodology for measurement and construction of the dependent variables discussed. Finally, the explanatory factors (independent variables) were operationalized, and their hypothesized associations with subsequent cost and schedule growth established.

In the next chapter, the relationships between the program outcome measures and the explanatory factors will be evaluated through various statistical tests, and findings will be presented.

IV. ANALYSIS AND TEST RESULTS

In Chapter III, the measures used to reflect program outcomes and explanatory factors were presented and described. In this chapter, the tests used to perform the analysis will first be discussed. The results from the analysis of relationships between the program outcomes and explanatory factors conducted using these tests will then be presented. This chapter contains only presentation and brief summaries of the results of the statistical tests; interpretation, generalization, discussion, and conclusions follow in Chapter V. Each program outcome (development cost growth, development schedule growth, total program cost growth) was examined separately. Tests were conducted on three separate samples: the full sample, and on two subsamples: aircraft and non-aircraft. This stratification was considered logical, because aircraft was the largest subsample of common weapon system type (n = 31). No other weapon system subsample was very large, so the remainder were lumped into the non-aircraft subsample (n = 58).

A. THE TESTS

The tests used during the analysis were univariate regression analysis, T-tests of means, and multivariate regression analysis. In describing how and why these tests were used, the following points shall be discussed: 1) What the test did, i.e., what it measured; 2) Why the test was used; what advantages it possessed that made it desirable, and how it overcame any disadvantages of the other tests; 3) What the test result (statistic) was, and what information it provided; 4) The criterion for significance for each test; and 5) Any comments pertinent to the test's performance or the results.

1. Univariate Regression Analysis

Univariate or simple regression analysis in essence describes and quantifies the nature of the relationship between two variables. By algebraically establishing the optimum linear relationship between an independent and a dependent variable, and comparing actual values to values predicted by the linear model, a conclusion may be reached about how well the independent variable (explanatory factor) explains the dependent variable (program outcome).

Univariate regression analysis was used because it allowed the isolation of a variable's contribution without concern for the influence of other factors due to multicollinearity, or the possible effect measurement errors in other variables may have on the test (a disadvantage of multivariate regression analysis).

Univariate regression analysis provides a wealth of descriptive statistics. In the current study two were used: the coefficient of the explanatory variable, and the coefficient of determination, adjusted for the degrees of freedom. (R-squared, adjusted[1]). The variable coefficient provided the nature of the relationship between the program outcome and explanatory factors, i.e., positive or negative association. Rsq adj., provided a measure of how well the explanatory factor explained the program outcome in each case.

A p-value of .05 was the criterion for significance. Less than or equal to .05 was regarded as significant, greater than .05 was not.

Outliers were frequently noted in this analysis. The largest outliers--as determined by computer software[2]--were deleted. For any single test, two or fewer outlier observations was the rule, and five was the maximum deleted.

2. <u>T-tests of Means</u>

Another type of univariate test, the T-test of means, was also performed. The essence of this test involved the creation of two subsamples--one with "low" values for a given program outcome, the other with "high" values--and determining if values for individual explanatory factors differed between these two subsamples. Top and bottom quartiles were used to form the "high" and "low" subsamples. For example, programs were ranked on DCG and the top and bottom groups separated out. Then values for an

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[1]Abbreviated "Rsq adj." in this study.

[2]Minitab.

explanatory variable, say Defense Spending, were compared between the two subsamples by using a T-test for the difference between the two sample means. Tests were constructed so that positive (negative) t-values indicated positive (negative) relationships between the dependent and independent variables in the test.

This test provided an analysis of the performance or impact of the explanatory factors at the "low" and "high" extremes of each of the program outcomes, where the relationships were expected to be strongest and least ambiguous.

As with univariate regression analysis, the criterion for significance was set at a p-value less than .05.

By excluding all programs that were not "low" or "high," this test was performed with approximately one-half the sample size of the other two tests. The result was that the power of the test was reduced, and only those comparisons with the greatest difference of means appeared as significant. This disadvantage is compensated for somewhat by the univariate regression tests, which used the entire sample. On the other hand, the t-test does not make the same linearity assumption inherent in the regression analysis.

2. Multivariate Regression Analysis

Multivariate Regression Analysis was also performed. This test provided quantification and description of the relationships between explanatory factors and program outcomes as did the univariate regression analysis, but provided control for the influences of other significant explanatory factors in the process. That is, the level of significance of any explanatory factor was tempered (or controlled for) by the presence of other factors.

This test provided a much stronger conceptual result than either the univariate regression or T-tests. By indicating which factors may interact in the real world to influence the program outcomes, it provided an excellent indication of their overall influence.

As with the univariate regression analysis, the coefficient of each explanatory variable was recorded as an indication of the relationship of the explanatory variable with the program outcome (i.e., positively or negatively associated). The partial coefficient of determination was computed and recorded for each significant explanatory factor as a measure of the strength of its ability to explain variation in the program outcome. This statistic, rather than Rsq adj., was used since the purpose of the multivariate analysis was to establish only which variables were significant within the test, and not their combined effect.

As with the other two tests, the significance criterion was a p-value less than .05.

The process of using multivariate regression analysis was both statistical and heuristic. Numerous multivariate regression models were constructed, with judgements made to eliminate observations or variables. The process included the following steps for each program outcome: first, each program outcome (dependent variable) was inspected for normality of distribution. All program outcomes approximated a normal distribution, and did not require transformation. Next, the program outcome was regressed against the entire group of explanatory variables. Those programs which contained outliers identified by the computer software were identified, and deleted. Typically, removed outliers amounted to one or two programs. The software also identified those measures for explanatory factors which were excessively intercorrelated with at least two other factors, and removed them. Explanatory factor measures removed for multicollinearity ranged from zero to as many as 11 of the 15. Next, the remaining programs were regressed. All the explanatory factors with extremely low T-ratios (less than .5) were then removed. The fourth step was to run the regression again with the remaining explanatory variables, removing the variable with the lowest insignificant T-ratio. The fifth step was to run the regression again, this time recording and inspecting the error terms and the Durbin-Watson test statistic, to ensure random distribution of the error terms. If all remaining measures were significant at this point, their variable coefficients and partial correlation coefficients were recorded. If not, the sixth step was to remove the independent variable with the lowest insignificant T-ratio and repeat steps five and six. Steps five and six were repeated until only significant independent variables remained. If fewer than two variables were significant, no multivariate regression result was considered to exist for that program outcome. Dashed lines (---) in the tables represent such results. Thus, unlike the other test result presentations in the later tables, only significant multivariate results are displayed.

B. THE RESULTS OF THE ANALYSIS

The remainder of this chapter presents the results of the statistical tests in table form and briefly summarizes the explanatory factors that most frequently appear to explain program outcomes. Interpretation, discussion, and conclusions to be drawn from the statistical results to be drawn from the statistical results are included in Chapter V.

1. Development Cost Growth

The results of the univariate regression, T-tests, and multivariate regression for Development Cost Growth are presented in Tables IV-1 through IV-3. Each significant result from each test is marked with an asterisk.

TABLE IV-1

DCG, ENTIRE SAMPLE

Indep. Variable	Univar. Regr. Coef.	Rsq-adj	T-tests T-ratio/ Relation-Ship	Multivar. Var. Coef.	Regr. Partial Corr. Coef.
ECON	.28	0.0%	1.14	---	---
CAPUTIL	.0146	1.4%	0.95	---	---
D-CAPUTIL	1.33	0.9%	1.66	---	---
DEFSPND	$-.3X10^{-5}$	2.6%	-3.14*	---	---
D-DEFSPND	.37	0.0%	-.11	---	---
ACQ ENV	-.0262*	4.9%*	-2.50*	---	---
PRES PARTY	.236	1.7%	-2.53*	---	---
HSE RATIO	.408	1.4%	2.11*	---	---
D-HSE RATIO	1.09*	4.8%*	1.27	---	---
SEN RATIO	.418*	3.8%*	2.69*	---	---
D-SEN RATIO	.056	0.0%	.98	---	---
CONG RATIO	.555*	3.9%*	2.89*	---	---
D-CONG RATIO	1.39	1.0%	1.14	---	---
PRO TYPE	.412*	4.2%*	1.56	---	---
PROG S/O	.0049	0.0%	1.01	---	---

* Significant at < .05.

The most frequently encountered significant explanatory factors in the analysis of DCG were SEN RATIO, ACQ ENV, and DEF SPND. The ECON, D-SEN RATIO, and D-CONG RATIO explanatory factors never appeared as significant results in any test, in the full sample or either of the

TABLE IV-2

DCG, AIRCRAFT SUBSAMPLE

Indep. Variable	Univar. Regr. Var. Coef.	Univar. Regr. Rsq-adj	T-tests T-ratio	Multivar. Var. Coef.	Regr. Partial Corr. Coef.
ECON	3.49	1.9%	1.31	---	---
CAPUTIL	.0295*	23.7%*	1.69	---	---
D-CAPUTIL	2.54*	22.5%*	1.66	.156*	.31*
DEFSPND	$-.4\times10^{-5}$*	20.2%*	-3.06*	---	---
D-DEFSPND	-.714	0.0%	-1.60	.230*	.83*
ACQ ENV	-.0329*	21.6%*	-3.16*	---	---
PRES PARTY	-.376*	14.9%*	-1.00	---	---
HSE RATIO	.516*	9.9%*	.49	---	---
D-HSE RATIO	-.876	0.7%	0.0	.142*	.44*
SEN RATIO	.699*	33.7%*	2.33*	.290*	.54*
D-SEN RATIO	-.229	0.0%	-.26	---	---
CONG RATIO	.829*	30.3%*	1.78	---	---
D-CONG RATIO	1.13	0.0%	-.62	---	---
PRO TYPE	3.49	1.9%	1.31	---	---
PROG S/O	.169	4.7%	1.88	.200*	.37*

* Significant at < .05.

subsamples. The ACQ ENV, SEN RATIO, and CONG RATIO explanatory factors were the most frequently occurring for the full sample. In the aircraft subsample, SEN RATIO occurred most frequently, and DEF SPND and D-HSE RATIO both occurred most frequently (once) in the non-aircraft subsample.

TABLE IV-3

DCG, NON-AIRCRAFT SUBSAMPLE

Indep. Variable	Univar. Regr. Var. Coef.	Rsq-adj	T-tests T-ratio	Multivar. Var. Coef.	Regr. Partial Corr. Coef.
ECON	.23	0.0%	-.12	---	---
CAPUTIL	.0052	0.0%	-.01	---	---
D-CAPUTIL	-.57	0.0%	.84	---	---
DEFSPND	$-.2X10^{-5}$	.1%	-2.33*	---	---
D-DEFSPND	.66	0.0%	.82	---	---
ACQ ENV	-.0253	2.8%	-1.75	---	---
PRES PARTY	-.078	0.0%	-1.31	---	---
HSE RATIO	.168	0.0%	.96	---	---
D-HSE RATIO	2.06*	7.7%*	1.35	---	---
SEN RATIO	.236	0.0%	1.44	---	---
D-SEN RATIO	-.29	0.0%	1.37	---	---
CONG RATIO	.286	0.0%	1.74	---	---
D-CONG RATIO	.974	1.5%	1.43	---	---
PRO TYPE	.337	2.1%	1.03	---	---
PROG S/O	.0003	0.0%	.90	---	---

* Significant at < .05.

The aircraft subsample had the largest number of significant explanatory factors within it, followed by the full sample. The non-aircraft subsample had the fewest.

C. TOTAL PROGRAM COST GROWTH

Tables IV-4 through IV-6 contain the results for TPCG. The three most frequently occurring significant explanatory factors in the TPCG analysis were HSE RATIO, CONG RATIO, and

TABLE IV-4

TPCG, ENTIRE SAMPLE

Indep. Variable	Univar. Regr. Var. Coef.	Univar. Regr. Rsq-adj	T-tests T-ratio	Multivar. Var. Coef.	Regr. Partial Corr. Coef.
ECON	3.45	0.0%	1.13	---	---
CAPUTIL	$-.5\times10^{-5}$*	5.7%*	.71	---	---
D-CAPUTIL	2.13	3.0%	1.35	---	---
DEFSPND	-.458*	7.7%	-3.07*	---	---
D-DEFSPND	.33	0.0%	-.27	---	---
ACQ ENV	-.0338*	7.1%*	-2.18*	---	---
PRES PARTY	-.32*	15.1%*	-3.28*	---	---
HSE RATIO	1.08*	15.1%*	3.87*	.78*	.415*
D-HSE RATIO	2.79*	16.5%*	2.06*	---	---
SEN RATIO	1.15*	18.0%*	2.48*	---	---
D-SEN RATIO	-.627	0.0%	.15	---	---
CONG RATIO	1.15*	18.0%*	3.27*	---	---
D-CONG RATIO	2.07	3.3%	1.20	---	---
PRO TYPE	.0691	3.5%	1.95	---	---
PROG S/O	3.45	0.0%	1.20	.124*	.34*

* Significant at < .05.

SEN RATIO. ECON, D-SEN RATIO, and PRO TYPE were not significant in any test for TPCG.

The HSE RATIO factor was the most pervasive explanatory factor in the full sample, significant in all three test results. Five different explanatory factors appeared in two of three test in the aircraft subsample: HSE RATIO, SEN RATIO, CONG RATIO, DEFSPND, and D-DEFSPND. Three factors

TABLE IV-5

TPCG, AIRCRAFT SUBSAMPLE

Indep. Variable	Univar. Regr. Var. Coef.	Rsq-adj	T-tests T-ratio	Multivar. Var. Coef.	Regr. Partial Corr. Coef.
ECON	-2.22	2.1%	.23	---	---
CAPUTIL	.00291	0.0%	.35	---	---
D-CAPUTIL	.974	4.3%	-.54	---	---
DEFSPND	$-.3X10^{-5}$*	39.5%*	-.96	---	---
D-DEFSPND	-2.12*	38.1%*	-3.42*	---	---
ACQ ENV	-.0271*	39.1%*	-4.38*	---	---
PRES PARTY	-.341*	39.3%*	-1.00	---	---
HSE RATIO	.417*	17.7%*	2.25*	---	---
D-HSE RATIO	1.05	6.5%	.86	---	---
SEN RATIO	.543*	56.1%*	3.67*	---	---
D-SEN RATIO	-.233	0.0%	-.40	---	---
CONG RATIO	.682*	51.9%*	4.00*	---	---
D-CONG RATIO	.419	0.0%	4.00*	---	---
PRO TYPE	-.097	0.0%	-.53	---	---
PROG S/O	.0574	0.0%	.36	---	---

* Significant at < .05.

were significant in two of three tests in the non-aircraft subsample: PRES PARTY, CONG RATIO, and PROG S/O.

The full sample had the largest number of significant explanatory factors within it, followed by the aircraft subsample. The non-aircraft subsample again had the fewest.

TABLE IV-6

TPCG, NON-AIRCRAFT SUBSAMPLE

Indep. Variable	Univar. Regr. Var. Coef.	Univar. Regr. Rsq-adj	T-tests T-ratio	Multivar. Regr. Var. Coef.	Multivar. Regr. Partial Corr. Coef.
ECON	7.08	2.0%	1.66	---	---
CAPUTIL	.0182	1.1%	.16	---	---
D-CAPUTIL	1.63	0.0%	-.10	---	---
DEFSPND	$-.5X10^{-6}$	4.7%	-2.24*	---	---
D-DEFSPND	.89	0.0%	-2.16*	---	---
ACQ ENV	-.0267	2.2%	-1.21	---	---
PRES PARTY	.366	1.0%	-1.76	---	---
HSE RATIO	.60*	12.0%*	3.38*	---	---
D-HSE RATIO	3.23*	20.6%*	.61	2.10*	.17*
SEN RATIO	.659	5.6%	2.75*	---	---
D-SEN RATIO	.471	0.0%	1.46	---	---
CONG RATIO	1.2*	11.9%*	2.60*	---	---
D-CONG RATIO	3.12	6.7%	-.95	---	---
PRO TYPE	-.086	0.0%	1.12	---	---
PROG S/O	.119*	8.0%*	1.34	.253*	.37*

* Significant at < .05.

D. DEVELOPMENT SCHEDULE GROWTH

The results of analysis for DSG are presented in Tables IV-7 through IV-9. The most frequently observed significant explanatory factors for DSG were HSE RATIO, D-HSE RATIO, and CONG RATIO. The most frequently occurring factor in the full sample was HSE RATIO, significant in all three tests. The CONG RATIO factor was the only factor significant in any test for the aircraft subsample, significant in only one

TABLE IV-7

DSG, ENTIRE SAMPLE

Indep. Variable	Univar. Regr. Var. Coef.	Univar. Regr. Rsq-adj	T-tests T-ratio	Multivar. Regr. Var. Coef.	Multivar. Regr. Partial Corr. Coef.
ECON	.67	0.0%	.74	---	---
CAPUTIL	.00971	1.1%	-.19	---	---
D-CAPUTIL	1.07	1.6%	1.35	---	---
DEFSPND	$-.1X10^{-5}$	0.1%	-1.01	---	---
D-DEFSPND	.398	0.0%	-.22	---	---
ACQ ENV	-.0118	1.4%	-.37	---	---
PRES PARTY	-.224*	4.0%*	-.98	---	---
HSE RATIO	.635*	11.7%*	2.05*	.423*	.17*
D-HSE RATIO	1.63*	13.8%*	1.66	1.12*	.05*
SEN RATIO	.594	10.6%	1.23	---	---
D-SEN RATIO	.092	0.0%	-.16	---	---
CONG RATIO	.466*	12.8%*	1.77	---	---
D-CONG RATIO	1.54*	4.4%*	1.37	---	---
PRO TYPE	.0462*	3.8%*	3.02*	.502*	.21*
PROG S/O	.0411	0.0%	.12	.116*	.075*

* Significant at < .05.

test. Seven different factors were significant in one test in the non-aircraft subsample (see Table IV-9). The ECON, CAPUTIL, D-CAPUTIL, DEFSPND, and ACQ ENV were not significant in any test for DSG.

TABLE IV-8

DSG, AIRCRAFT SUBSAMPLE

Indep. Variable	Univar. Regr. Var. Coef.	Rsq-adj	T-tests T-ratio	Multivar. Var. Coef.	Regr. Partial Corr. Coef.
ECON	.38	0.0%	.68	---	---
CAPUTIL	.00062	0.0%	-.92	---	---
D-CAPUTIL	.031	0.0%	-.39	---	---
DEFSPND	$-.1X10^{-6}$	.4%	-.88	---	---
D-DEFSPND	-.701	3.7%	-.85	---	---
ACQ ENV	.004	0.0%	-.42	---	---
PRES PARTY	-.132	5.7%	-.83	---	---
HSE RATIO	.204	5.0%	.74	---	---
D-HSE RATIO	-.257	0.0%	.72	---	---
SEN RATIO	.149	4.0%	.57	---	---
D-SEN RATIO	1.17	2.5%	1.07	---	---
CONG RATIO	.23*	7.1%*	.73	---	---
D-CONG RATIO	.257	0.0%	1.27	---	---
PRO TYPE	.063	0.0%	-.60	---	---
PROG S/O	.11	5.2%	1.79	---	---

* Significant at < .05.

TABLE IV-9

DSG, NON-AIRCRAFT SUBSAMPLE

Indep. Variable	Univar. Var. Coef.	Regr. Rsq-adj	T-tests T-ratio	Multivar. Var. Coef.	Regr. Partial Corr. Coef.
ECON	.93	0.0%	.91	---	---
CAPUTIL	.0103	0.2%	-.17	---	---
D-CAPUTIL	-.01	0.0%	-.43	---	---
DEFSPND	$-.1\text{X}10^{-5}$	0.0%	-.96	---	---
D-DEFSPND	.562	0.0%	3.16*	---	---
ACQ ENV	.018	3.2%	-.83	---	---
PRES PARTY	-.138	0.0%	-.70	---	---
HSE RATIO	.726*	9.8%*	1.99	---	---
D-HSE RATIO	2.57*	29.4%*	-.34	---	---
SEN RATIO	.379*	4.7%*	1.37	---	---
D-SEN RATIO	.009	0.0%	2.35*	---	---
CONG RATIO	.660*	9.2%*	1.78	---	---
D-CONG RATIO	2.55*	11.5%*	-.72	---	---
PRO TYPE	.111	0.0%	2.37*	---	---
PROG S/O	.0163	0.0%	.54	---	---

* Significant at < .05.

E. SUMMARY OF ANALYSIS

Across all tests on all samples, HSE RATIO and CONG RATIO were the most frequently significant explanatory factors, followed by SEN RATIO and D-HSE RATIO. Only ECON failed to occur in any test for any sample.

The explanatory factor occurring most frequently in the three full sample tests was HSE RATIO. The ECON, DEFSPND and D-CONG RATIO explanatory factors were the least frequently occurring in these tests.

For tests conducted on aircraft subsamples, SEN RATIO and CONG RATIO were the most frequently occurring significant explanatory factors. The least frequently occurring were D-CONG RATIO again, and PRO TYPE, neither of which was significant in any test. For the non-aircraft subsamples, DEFSPND and D-HSE RATIO were the most frequently significant explanatory factors. Six explanatory factors (besides ECON) were never significant on any test result for these subsamples: CAPUTIL, D-DEFSPND, ACQ ENV, SEN RATIO, CONG RATIO, and PROG S/O.

In this chapter, each of the three program outcome factors were tested for significant relationships with the explanatory factors. The tests used were univariate and multivariate regression, and T-tests of means. These tests were conducted on three separate samples for each program outcome: the full sample, the aircraft program subsample, and the non-aircraft subsample. The statistical results were presented and summarized.

These findings will be used in the next chapter to develop conclusions regarding the hypothesized relationships between the program outcomes and the explanatory factors.

V. CONCLUSIONS AND RECOMMENDATIONS

In this chapter, the analysis conducted in the earlier chapters will be summarized. This will be followed by a discussion of the conclusions that may be drawn from the results of the analysis. Limitations and constraints encountered in this study will then be briefly reviewed, followed by suggestions for future research in areas related to this study.

A. SUMMARY OF THE STUDY

The intent of this study has been to establish the nature and extent of relationships between cost and schedule growth during weapons system acquisition and economic, political, and program-related explanatory factors.

In Chapter II, the results of a review of the literature to identify possible explanatory factors influencing cost and schedule growth were presented. A scenario relating each factor to cost and schedule growth was also presented, along with a formal hypothesis stating the expected relationship.

Chapter III was devoted to describing the sample, the measures of cost and schedule growth, and the measures of the explanatory factors that would be used in the subsequent analysis. Three program outcome measures were chosen for analysis in this st···. Development Cost Growth, Total Program Cost Growth, and Development Schedule Growth.

In Chapter IV, the various tests used in the analysis were presented and discussed. The results of the analysis were then presented in tabular form, and summarized.

B. CONCLUSIONS

The objective of this study is to draw some initial general conclusions concerning the relationship between economic/political conditions and program outcomes. Doing so requires abstracting some broad findings from the detailed statistical results. This process is hampered by three characteristics of the analysis:

- The use of several types of statistical tests to examine the same hypothesized relationship.
- Conducting the tests on multiple samples.
- The examination of multiple program outcomes.
- The use of multiple, sometimes related variables to measure a single broad construct.

A difficulty in drawing general conclusions is encountered when the results from the from the multipla tests, samples, outcomes and measures are not the same.

The solution selected to counter this problem was to look for broad patterns in the results. Fundamentally, more attention was paid to results that were: a) significant; b) consistent across statistical tests; and c) consistent across the samples.

In order to identify patterns to graphically portray the results, Table V-1 was created. It is acknowledged that such a "summary table" is not a perfect solution to the problem, because the tests are not statistically independent, and because counting a number of individual significant results does not fully reflect the differences in strength that each individual result may possess. Nonetheless, it is a workable solution to the problem, allowing the synthesis and generalization needed to reach conclusions.

An examination of the table brings several points into focus. First, three measures of Congressional Majority Party--HSE RATIO, SEN RATIO, and CONG RATIO--stand out clearly as the most pervasive, in both the number of tests and samples in which they are significant. Note, however, that these results are inconsistent with the hypothesized relationships. According to the results, Democratic congressional majorities, not Republican, are associated with increased cost and schedule growth.

This result cannot be easily explained. One possible explanation is that when Democrats hold the majority in Congress, they are able to reduce appropriations for established programs, leading to program stretch out, which Tyson, et al., found to be directly related to cost and schedule growth.

TABLE V-1

PROGRAM OUTCOMES

	Program Outcomes								
	DCG			TPCG			DSG		
Samples:	F	A	N	F	A	N	F	A	N
FACTORS:									
ECON									
CAPUTIL		/		*					
D-CAPUTIL		//							
DEFSPND	*	**	*	**	*	*			
D-DEFSPND		*			**	*			/
ACQ ENV	//	//		//	//				
PRES PARTY	/	/		//	/		//		
HSE RATIO	/	/		///	//	//	///		/
D-HSE RATIO	/	/	/	//		//	//		/
SEN RATIO	//	///		//	//	/			/
D-SEN RATIO									/
CONG RATIO	//	/		//	//	//	/	/	/
D-CONG RATIO					/		/		/
PRO TYPE	/						///		/
PROG S/O		*		*		**	*		

LEGEND: F = Full Sample
A = Aircraft Subsample
N = Non-aircraft Subsample

KEY: *** = 3 of 3 Tests Significant; Hypothesized Relationship
** = 2 of 3 Tests Significant; Hypothesized Relationship
* = 1 of 3 Tests Significant; Hypothesized Relationship

/// = 3 of 3 Tests Significant; Opposite Relationship
// = 2 of 3 Tests Significant; Opposite Relationship
/ = 1 of 3 Tests Significant; Opposite Relationship

Another scenario is that, when Democrats have stronger control of Congress, Presidential administrations, particularly Republican, bias initial cost estimates downward in an attempt to gain program acceptance. Cost growth then results when actual costs are higher. This scenario is not fully compatible with the results noted for the Presidential Party explanatory factor, however. In that result, Republican presidents are associated with relatively lower cost and schedule growth. Nonetheless, these results do suggest that programs initiated under both Democratically dominated Congresses and Democratic Presidential administrations have been characterized by greater cost and schedule growth.

Another point of interest is the complete lack of significance of Economy Wide Conditions. This seems contrary to the common sense notion that places the economy at the heart of all market-related transactions.

One possible explanation for this factor's lack of significance may be that the measure of change in economic condition was not of sufficient duration to reflect aspects of the economy that would impact cost or schedule outcomes.

Table V-1 also makes clear that TPCG was the program outcome best explained by the explanatory factors, followed by DCG and DSG. This brings up a couple of additional points. First, weapon system cost growth appears to be much more strongly related to the influence of political and economic factors than is schedule growth: TPCG and DCG each have noticeably more significant results as does DSG. This seems to make sense, since the mechanism for controlling most weapon system programs is cost, not time. This suggests that schedule growth is a by-product of cost growth. Second, since TPCG is the only program outcome measure which reflects performance during production, its dominance in this study underscores the need for additional study of production phase cost and schedule growth.

Finally, it is apparent that the full sample contained the largest number of significant results across all three program outcomes, followed by the aircraft subsample. This is not a surprising result, since the full sample was much larger than either of the subsamples. What is somewhat surprising is that the aircraft subsample (n = 31) had half again as many significant results as the non-aircraft subsample (n = 58). This result is important because it points out rather dramatically the importance of homogeneous sample groups. The explanatory ability of the tests were significantly greater for the smaller, homogeneous aircraft subsample, where differences in equipment type was in effect controlled for.

C. LIMITATIONS AND CONSTRAINTS

Certain aspects of this study placed constraints upon the analysis, contributing to the ambiguity of results and reducing the facility of drawing more substantive conclusions. Limitations related to hypothesis construction, sample size, sample composition, measures used, and statistical tests all merit comment.

1. Hypothesis Construction

The objective of constructing the hypotheses was to put a relatively simple conceptual "handle" on complex relationships involving real-life phenomena. In reducing complex interactions to a simple, testable form, however, much of the richness of real-life is ignored. Since the true nature of the relationships being explored is ambiguous, simple direct tests of simple direct hypotheses may miss providing evidence of relationships that are more subtle. Reducing phenomena to simple, testable relationships is a reasonable approach in an initial study. Future studies however could benefit from more complex hypotheses, particularly concerning presidential and congressional parties. Testing hypotheses that capture interactions between the two branches of government would likely provide future insight into pressures that influence cost estimates and cost growth.

2. Sample Size

Tyson, et al.'s sample of 89 programs was originally considered adequate to meet the needs of the planned tests. As the desirability of stratifying the sample became apparent, however, the sample size was less suitable. This was most perceptible in the T-tests. Due to the method of their construction, as few as eight programs were available for the "low" and "high" mean calculations, significantly reducing the power of these tests.

Regression analysis in the aircraft subsamples were impacted, as well. These samples were reduced from their original size of 31 programs to as few as 21, due to missing data items for some of the explanatory factors and outlier removal. This reduced the sensitivity of the tests, increasing the required value of the T-statistic to achieve the desired level of confidence in the test result.

3. Sample Composition

The composition of the sample--many different types of programs over a period of several decades--may also have created a problem in reaching more consistent results. This was demonstrated by the comparison of results for the aircraft and non-aircraft subsamples made in the conclusions. By including all non-aircraft systems in one subsample, many different kinds of programs were brought together to try and explain a single program outcome. The results, as might be expected, were more less significant than when all observations were of the same kind, as in the aircraft subsample.

4. Measures

One of the benefits of using Tyson, et al.'s program outcome measures was that they were already constructed and conceptually rather simple. A drawback, however, was that the raw data used for construction were not included in their study. Had these data been available, dates for the start and end of the production phase would have been available. Knowledge of these dates would have permitted an expanded, more comprehensive analysis, in two respects. First, relationships between explanatory factors and production cost/schedule growth could have been conducted. Second, measures of the explanatory factors at various different points in time during the duration of a program could have been constructed. Instead, the explanatory measure used in this study primarily reflected conditions only at the start of FSD. These limitations result in the current conclusions being only preliminary.

5. Statistical Tests Used

As noted in Chapter IV, each of the tests used had certain drawbacks that were to varying degrees compensated for by the inclusion of one or both of the other tests. The need to use three different tests, each with its own individual statistical result created difficulty in drawing overall, general conclusions when individual test results were inconsistent. This limitation can not be "corrected" per se, but is important to remember when interpreting this study's results and evaluating its conclusions.

D. RECOMMENDATIONS FOR FURTHER STUDY

Four issues were identified during the course of this study that warrant further research. These issues were:

Production Cost and Schedule Growth, the relationship of Congressional Majority Party to the program outcomes, the relationship of Economy Wide Conditions to the program outcomes, and the relationship of Program Type to the program outcomes.

While this study does provide some preliminary indications about the relationships between cost and schedule growth and political and economic factors, it falls well short of developing useful tools for potential users. In future studies, program outcome and explanatory factors constructed using production phase as well as development phase data should be developed.

The cause of the positive correlation between Congressional Majority Party and cost and schedule growth deserves further analysis, as well. As noted in the conclusions, Democratic Party majorities in Congress were associated with relatively greater cost and schedule growth, yet there was no fully satisfactory explanation for this conclusion consistent with the finding for presidential party.

Finally, the effect of Program Type needs further evaluation. This factor's poor explanatory ability in this study runs counter to what common sense would indicate: modified programs should experience less cost and schedule growth. As noted, one problem encountered in this study was the lack of production phase data. Intuitively, this was the area where the most significant reductions in cost and schedule growth should be realized, through the effect of learning curves. The question of how Program Type influences cost and/or schedule growth is still open; additional study is needed to close it.

This study has taken a preliminary step in the identification and investigation of some of the less technical--but critically important--factors that make up and impact the slow and expensive weapon procurement system.

Further research in the areas of politics and economics may provide insights that military and civilian budgeters, program managers, and policy makers can employ to contain the costs in time and money of providing the U.S. Military with the tools it needs to perform its numerous and complex missions.

APPENDIX

COST, SCHEDULE AND EXPLANATORY FACTOR MEASURES

Program Name	Contractor	DCG	DSG	TPCG
V-22	BELL/BOEING	0.99	1	0.94
T45TS	MCDONNELL DOUGLASS	0.44	1.04	0.97
B-1A	ROCKWELL	1.1	1.17	*
C-5B	LOCKHEED	1	0.77	*
C-17A	MCDONELL DOUGLASS	1.2	1.05	1.04
C-5A	LOCKHEED	0.98	1.18	1.77
B-1B	ROCKWELL	0.96	1	0.95
FB-111A	GENERAL DYNAMICS	2.57	1.42	*
AV-8A	MCDONNELL DOUGLASS	0.99	1	*
F-5E	NORTHROP	1.05	1.06	*
F-15	MCDONNELL DOUGLASS	1.07	1.03	1.16
F-16	GENERAL DYNAMICS	1.05	0.98	1.19
F-14D	GRUMMAN	1.07	1	0.82
F-14A	GRUMMAN	1.44	1.16	1.28
AV-8B	MCDONNELL DOUGLASS	1.11	0.83	0.82
A-10	FAIRCHILD	1.27	1.08	1.33
F/A-18	MCDONNELL DOUGLASS	1.15	1.08	1.37
E-6A	BOEING	1.12	1.27	*
E-3A	BOEING	1.37	1.16	1.25
EF-111A	GRUMMAN	2.1	1.7	1.73
E-2C	GRUMMAN	1.5	0.76	*
EA-6B	GRUMMAN	1.26	1	*
P-3C	LOCKHEED	1.8	1	1.42
LAMPSMK3	SIKORSKY	1.04	1	1.13
E-4	BOEING	1.88	1.59	1.07
S-3A	LOCKHEED	1.09	1	1.3
CH-47D	BOEING VERTOL	1.13	1.06	1.33
OH-58D	BELL	0.98	1.2	1.26
UH-60A	SIKORSKY	1.08	1.07	1.22
AH-64A	HUGHES/M.D.HELO	1.26	1.49	1.59
CHEYENNE	SIKORSKY	2.09	1	*
PHOENIX - A	HUGHES	1.54	1.07	1.39
AMRAAM	HUGHES	1.44	1.8	1.06
HELLFIRE	ROCKWELL	1.09	1.44	1.39
HARM	TEXAS INSTRUMENTS	2.03	1.05	1.47
SPARROW F	GENERAL DYNAMICS	4.25	3.9	1.74
TOW	HUGHES	1.2	1.45	1.7
SIDEWINDER L	FORD AERO	4.89	2.45	2.25
TOW2	HUGHES	1.7	1.02	0.98
HARPOON	MCDONNELL DOUGLASS	1.17	1.36	1.53

MAVERICK D/G	HUGHES	1.07	1.98	1.53
SPARROW E	GENERAL DYNAMICS	0.84	1	1.07
SPARROW M	GENERAL DYNAMICS	0.98	1.46	1.29
SIDEWINDER M	FORD AERO	2.04	1.01	1.1
PHOENIX C	HUGHES	1.67	1.45	1.93
ADDS	HUGHES	1.32	1.54	*
MLS	BENDIX	0.83	1.08	*
JTIDS	HUGHES	3.11	1.46	*
JSTARS	GRUMMAN	1.18	1	*
WIS	ITT	1.6	2.11	*

Program Name	Contractor	DCG	DSG	TPCG
SINCGARS	ITT	1.35	1.29	*
ASPJ	ITT	2.36	1.69	*
LANTIRN	MARTIN MARIETTA	0.96	1	*
TRI TAC	SYLVANIA	1.03	1	*
OTH B	GENERAL ELECTRIC	1.22	1.44	*
DMSP	RCA	1	1	0.95
NAVSTAR GPS	ROCKWELL	0.99	1.44	1.08
DSP	TRV	1.35	1	1.06
DSCS III	GENERAL ELECTRIC	2.54	1.59	1.99
ROLAND	BOEING	1.52	2.15	4.17
IMP. HAWK	RAYTHEON	1.87	1.25	1.48
SHELLAGH	MARTIN MARIETTA	1.31	1.05	1.45
MK 48 AD	HUGHES	1.01	1.35	1.73
MLRS	LTV MISSLES	1.03	1	0.95
MK 50	HONEYWELL	1.27	1.29	1.08
STINGER P	GENERAL DYNAMICS	1.02	1.95	*
MK 48	GOULD	[illegible]	0.89	1.08
STINGER B/A	GENERAL DYNAMICS	1.46	2.46	1.75
COPPERHEAD	MARTIN MARIETTA	1.28	1.75	2.12
DIVAD	FORD AERO	1.6	1.74	2.33
FIVE INCH	MARTIN MARIETTA	1.16	1	*
STINGER R	GENERAL DYNAMICS	1.02	1.18	*
DRAGON	MCDONNELL DOUGLASS	1.88	2.14	2.6
PERSHING 2	MARTIN MARIETTA	1	0.83	1.67
PATRIOT	RAYTHEON	1.4	1.15	1.67
STD MISSLE 2	GENERAL DYNAMICS	1.44	1	0.96
LANCE	LTV MISSLES	1.08	1.46	1.12
PEACEKEEPER	MARTIN MARIETTA	0.96	1	1.28
GLCM	GENERAL DYNAMICS	3.48	1.3	1.67
TOMAHAWK	GENERAL DYNAMICS	1.66	1.48	1.57
SRAM II	BOEING	1	1.19	0.81
MINUTEMAN2	BOEING	1	1.71	1.06
TRIDENT 2	LOCKHEED	0.93	1	0.97
ICBM	MARTIN MARIETTA	0.31	1	*
ALCM	BOEING	1.37	1.34	1.17
SRAM	BOEING	2.8	2.03	3.39
MINUTEMAN3	BOEING	0.98	0.87	1.39

CONDOR	ARGENTINA	1.72	3	5.19
MAVERICK A	HUGHES	1.15	1.46	0.95

Program Name	ACQ ENV	CAPUTIL	D-CAPUTIL	DEFSPND	D-DEFSPND	PRES PARTY
V-22	86	*	*	273375	0.08	1
T45TS	82	68.88	-0.13	185309	0.18	1
B-1A	70	69.83	-0.15	81692	0.05	1
C-5B	82	68.88	-0.13	185309	0.18	1
C-17A	85	*	*	252748	0	1
C-5A	65	83.76	0.03	50620	-0.08	0
B-1B	82	68.88	-0.13	185309	0.18	1
FB-111A	66	91.82	0.1	58111	0.15	0
AV-8A	70	69.83	-0.15	81692	0.05	1
F-5E	72	67.43	0.06	79174	0	1
F-15	70	69.83	-0.15	81692	0.05	1
F-16	75	71.43	0	86509	0	0
F-14D	84	*	*	227413	0.08	1
F-14A	69	82.28	-0.05	82497	0.01	1
AV-8B	80	86.8	-0.02	133995	0.15	1
A-10	73	74.28	0.1	76681	-0.03	1
F/A-18	76	69.17	0	89619	0	0
E-6A	83	*	-1	209903	0.13	1
E-3A	70	69.83	-0.15	81692	0.05	1
EF-111A	75	71.43	0	86509	0	0
E-2C	70	69.83	-0.15	86509	0.05	1
EA-6B	68	87.02	-0.05	81926	0.15	1
P-3C	65	83.76	0.03	50620	-0.08	0
LAMPSMK3	77	71.38	0.03	97241	0.09	0
E-4	73	74.28	0.1	76681	-0.03	1
S-3A	69	82.28	-0.05	82497	0.01	1
CH-47D	75	71.43	0	86509	0	0
OH-58D	81	78.83	-0.09	157513	0.18	1
UH-60A	72	67.43	0.06	79174	0	1
AH-64A	76	69.17	0	89619	0	0
CHEYENNE	66	91.82	0.1	58111	0.15	0
PHOENIX - A	62	77.18	0.15	52345	0.09	0
AMRAAM	82	68.88	-0.13	185309	0.18	1
HELLFIRE	76	69.17	0	89619	0	0
HARM	78	79.39	0.11	104495	0.07	0
SPARROW F	66	91.82	0.1	58111	0.15	0
TOW	63	83.02	0.08	53400	0.02	0
SIDEWINDER L	71	63.48	-0.09	78872	-0.03	1
TOW2	78	79.39	0.11	104495	0.07	0
HARPOON	73	74.28	0.1	76681	-0.03	1
MAVERICK D/G	76	69.17	0	89619	0	0
SPARROW E	60	66.91	-0.05	48130	-0.02	0
SPARROW M	78	79.39	0.11	104495	0.07	0
SIDEWINDER M	76	69.17	0	89619	0	0
PHOENIX C	77	71.38	0.03	97241	0.09	0

ADDS	85	*	*	252748	0.11	1
MLS	88	*	*	290361	0.03	1
JTIDS	81	78.83	-0.09	157513	0.18	1
JSTARS	84	*	*	227413	0.08	1

Program Name	ACQ ENV	CAPUTIL	D-CAPUTIL	DEFSPND	D-DEFSPND	PRES PARTY
WIS	85	*	*	252748	0.11	1
SINCGARS	78	79.39	0.11	104495	0.07	0
ASPJ	81	78.83	-0.09	157513	0.18	1
LANTIRN	80	86.8	-0.02	133995	0.15	1
TRI TAC	75	71.43	0	86509	0	0
OTH B	82	68.88	-0.13	185309	0.18	1
DMSP	76	69.17	0	89619	0	0
NAVSTAR GPS	79	88.87	0.12	116342	0.11	0
DSP	67	91.23	-0.01	71417	0.23	0
DSCS III	76	69.17	0	89619	0	0
ROLAND	75	71.43	0	86509	0	0
IMP. HAWK	64	81.66	-0.02	54757	0.03	0
SHELLAGH	59	70.46	*	49015	*	1
MK 48 AD	82	68.88	-0.13	185309	0.18	1
MLRS	76	69.17	0	89619	0	0
MK 50	83	*	-1	209903	0.13	1
STINGER P	77	71.38	0.03	97241	0.09	0
MK 48	68	87.02	-0.05	81926	0.15	0
STINGER B/A	75	71.43	0	86509	0	0
COPPERHEAD	75	71.43	0	86509	0	0
DIVAD	77	71.38	0.03	97241	0.09	0
FIVE INCH	77	71.38	0.03	97241	0.09	0
STINGER R	84	*	*	227413	0.08	1
DRAGON	66	91.82	0.1	58111	0.15	0
PERSHING 2	79	88.87	0.12	116342	0.11	0
PATRIOT	72	67.43	0.06	79174	0	1
STD MISSLE 2	72	67.43	0.06	79174	0	1
LANCE	67	91.23	-0.01	71417	0.23	0
PEACEKEEPER	78	79.39	0.11	104495	0.07	0
GLCM	78	79.39	0.11	104495	0.07	0
TOMAHAWK	77	71.38	0.03	97241	0.09	0
SRAM II	87	*	*	281999	0.03	1
MINUTEMAN2	65	83.76	0.03	50620	-0.08	0
TRIDENT 2	83	*	-1	209903	0.13	1
ICBM	86	*	*	273375	0.08	1
ALCM	77	71.38	0.03	97241	0.09	0
SRAM	66	91.82	0.1	58111	0.15	0
MINUTEMAN3	66	91.82	0.1	58111	0.15	0
CONDOR	66	91.82	0.1	58111	0.15	0
MAVERICK A	68	87.02	-0.05	81926	0.15	1

Program Name	HSE RATIO	D-HSE RATIO	SEN RATIO	D-SEN RATIO	CONG RATIO	D-CONG RATIO
V-22	1.43	-0.02	1.17	0	1.3	-0.01
T45TS	1.6	0.15	0.82	-0.04	1.21	0.08
B-1A	1.3	-0.01	1.33	0	1.315	0
C-5B	1.6	0.15	0.82	-0.04	1.21	0.08
C-17A	1.46	0	1.17	0	1.315	0
C-5A	1.65	0.15	2.13	0.05	1.89	0.09
B-1B	1.6	0.15	0.82	-0.04	1.21	0.08
FB-111A	2.09	0.27	2.03	-0.05	2.06	0.09
AV-8A	1.3	-0.01	1.33	0	1.315	0
F-5E	1.37	0	1.33	0.08	1.35	0.04
F-15	1.3	-0.01	1.33	0	1.315	0
F-16	2.01	0	1.61	0	1.81	0
F-14D	1.39	-0.09	1.13	0.27	1.26	0.05
F-14A	1.31	-0.01	1.33	-0.25	1.32	-0.15
AV-8B	1.28	-0.15	0.83	-0.05	1.055	-0.11
A-10	1.29	-0.06	1.39	0.05	1.34	-0.01
F/A-18	2.01	0	1.61	0	1.81	0
E-6A	1.52	-0.05	0.89	0.09	1.205	0
E-3A	1.3	-0.01	1.33	0	1.315	0
EF-111A	2.01	0	1.61	0	1.81	0
E-2C	1.3	-0.01	1.33	0	1.315	0
EA-6B	1.32	-0.26	1.78	0	1.55	-0.13
P-3C	1.65	0.15	2.13	0.05	1.89	0.09
LAMPSMK3	1.89	-0.06	1.41	-0.12	1.65	-0.09
E-4	1.29	-0.06	1.39	0.05	1.34	-0.01
S-3A	1.31	-0.01	1.33	-0.25	1.32	-0.15
CH-47D	2.01	0	1.61	0	1.81	0
OH-58D	1.39	0.09	0.85	0.02	1.12	0.06
UH-60A	1.37	0	1.33	0.08	1.35	0.04
AH-64A	2.01	0	1.61	0	1.81	0
CHEYENNE	2.09	0.27	2.03	-0.05	2.06	0.09
PHOENIX - A	1.51	-0.07	1.78	-0.04	1.645	-0.11
AMRAAM	1.6	0.15	0.82	-0.04	1.21	0.08
HELLFIRE	2.01	0	1.61	0	1.81	0
HARM	1.72	-0.09	1.41	0	1.565	-0.05
SPARROW F	2.09	0.27	2.03	-0.05	2.06	0.09
TOW	1.47	-0.03	2.03	0.14	1.75	0.06
SIDEWINDER L	1.37	0.05	1.23	-0.08	1.3	-0.01
TOW2	1.72	-0.09	1.41	0	1.565	-0.05
HARPOON	1.29	-0.06	1.39	0.05	1.34	-0.01
MAVERICK D/G	2.01	0	1.61	0	1.81	0
SPARROW E	1.83	*	1.86	*	1.845	*
SPARROW M	1.72	-0.09	1.41	0	1.565	-0.05
SIDEWINDER M	2.01	0	1.61	0	1.81	0
PHOENIX C	1.89	-0.06	1.41	-0.12	1.65	-0.09
ADDS	1.46	0.05	1.17	0.04	1.315	0.04
MLS	*	*	*	*	*	*

JTIDS	1.39	0.09	0.85	0.02	1.12	0.06
JSTARS	1.39	-0.09	1.13	0.27	1.26	0.05

Program Name	HSE RATIO	D-HSE RATIO	SEN RATIO	D-SEN RATIO	CONG RATIO	D-CONG RATIO
WIS	1.46	0.05	1.17	0.04	1.315	0.04
SINCGARS	1.72	-0.09	1.41	0	1.565	-0.05
ASPJ	1.39	0.09	0.85	0.02	1.12	0.06
LANTIRN	1.28	-0.15	0.83	-0.05	1.055	-0.11
TRI TAC	2.01	0	1.61	0	1.81	0
OTH B	1.6	0.15	0.82	-0.04	1.21	0.08
DMSP	2.01	0	1.61	0	1.81	0
NAVSTAR GPS	1.51	-0.12	0.87	-0.38	1.19	-0.24
DSP	1.78	-0.15	1.78	-0.12	1.78	-0.14
DSCS III	2.01	0	1.61	0	1.81	0
ROLAND	2.01	0	1.61	0	1.81	0
IMP. HAWK	1.44	-0.02	2.03	0	1.735	-0.01
SHELLAGH	*	*	*	*	*	*
MK 48 AD	1.6	0.15	0.82	-0.04	1.21	0.08
MLRS	2.01	0	1.61	0	1.81	0
MK 50	1.52	-0.05	0.89	0.09	1.205	0
STINGER P	1.89	-0.06	1.41	-0.12	1.65	-0.09
MK 48	1.32	-0.26	1.78	0	1.55	-0.13
STINGER B/A	2.01	0	1.61	0	1.81	0
COPPERHEAD	2.01	0	1.61	0	1.81	0
DIVAD	1.89	-0.06	1.41	-0.12	1.65	-0.09
FIVE INCH	1.89	-0.06	1.41	-0.12	1.65	-0.09
STINGER R	1.39	-0.09	1.13	0.27	1.26	0.05
DRAGON	2.09	0.27	2.03	-0.05	2.06	0.09
PERSHING 2	1.51	-0.12	0.87	-0.38	1.19	-0.24
PATRIOT	1.37	0	1.33	0.08	1.35	0.04
STD MISSLE 2	1.37	0	1.33	0.08	1.35	0.04
LANCE	1.78	-0.15	1.78	-0.12	1.78	-0.14
PEACEKEEPER	1.72	-0.09	1.48	0	1.6	-0.05
GLCM	1.72	-0.09	1.48	0	1.6	-0.05
TOMAHAWK	1.89	-0.06	1.41	-0.12	1.65	-0.09
SRAM II	*	-1	*	-1	0	-1
MINUTEMAN2	1.65	0.15	2.13	0.05	1.89	0.09
TRIDENT 2	1.52	-0.05	0.89	0.09	1.205	0
ICBM	1.43	-0.02	1.17	0	1.3	-0.01
ALCM	1.89	-0.06	1.41	-0.12	1.65	-0.09
SRAM	2.09	0.27	2.03	-0.05	2.06	0.09
MINUTEMAN3	2.09	0.27	2.03	-0.05	2.06	0.09
CONDOR	2.09	0.27	2.03	-0.05	2.06	0.09
MAVERICK A	1.32	-0.26	1.78	0	1.55	-0.13

Program Name	PRO TYPE	PROG S/O	ECON
V-22	0	1.68	0.032
T45TS	1	1	-0.026
B-1A	0	*	0.036
C-5B	1	0.99	-0.026
C-17A	0	0.92	0.039
C-5A	0	1.803	-0.02
B-1B	1	1	-0.026
FB-111A	1	*	0.014
AV-8A	0	1.0417	0.036
F-5E	1	*	-0.026
F-15	0	1.9425	0.036
F-16	0	0.7952	0.021
F-14D	1	0.5723	-0.08
F-14A	0	2.5238	-0.037
AV-8B	1	1.5488	0.014
A-10	0	0.98	0.032
F/A-18	0	1.1793	-0.037
E-6A	0	*	0.028
E-3A	0	3.2027	0.036
EF-111A	1	1.86	0.021
E-2C	1	*	0.036
EA-6B	1	*	0.01
P-3C	1	1.6667	-0.02
LAMPSMK3	0	1.89	0.002
E-4	0	2	0.032
S-3A	0	1.0526	-0.037
CH-47D	1	0.8182	0.021
OH-58D	1	3	-0.015
UH-60A	0	1	-0.026
AH-64A	0	0.8095	-0.037
CHEYENNE	0	*	0.014
PHOENIX - A	0	1.2245	-0.046
AMRAAM	0	1.11	-0.026
HELLFIRE	0	1.202	-0.037
HARM	0	1.5333	0.03
SPARROW F	1	1.1627	0.014
TOW	0	3.8475	-0.003
SIDEWINDER L	1	2.2439	-0.014
TOW2	1	1.0562	0.03
HARPOON	0	3.2105	0.032
MAVERICK D/G	1	1.0974	-0.037
SPARROW E	1	9.1471	*
SPARROW M	1	1.1667	0.03
SIDEWINDER M	1	1.0749	-0.037
PHOENIX C	1	0.7794	0.002
ADDS	0	*	0.039
MLS	0	*	0.063

JTIDS	0	*	-0.015
JSTARS	0	*	-0.08

Program Name	PRO TYPE	PROG S/O	
WIS	0	*	0.039
SINCGARS	0	*	0.03
ASPJ	0	*	-0.015
LANTIRN	0	*	0.014
TRI TAC	0	*	0.021
OTH B	0	*	-0.026
DMSP	0	0.885	-0.037
NAVSTAR GPS	0	1.2164	0.001
DSP	0	0.8163	0.014
DSCS III	0	1.0833	-0.037
ROLAND	1	5.3333	0.021
IMP. HAWK	1	2.1208	0.041
SHELLAGH	0	1.618	*
MK 48 AD	*	0.91	-0.026
MLRS	0	1.1732	-0.037
MK 50	0	0.86	0.028
STINGER P	1	*	0.002
MK 48	0	2.3382	0.01
STINGER B/A	0	1.0182	0.021
COPPERHEAD	0	5.4211	0.021
DIVAD	0	6.3	0.002
FIVE INCH	0	*	0.002
STINGER R	1	*	-0.08
DRAGON	0	4.1852	0.014
PERSHING 2	1	2.0563	0.001
PATRIOT	0	2.2727	-0.026
STD MISSLE 2	1	1.2279	-0.026
LANCE	0	0.93	0.014
PEACEKEEPER	0	1.8095	0.03
GLCM	1	1.625	0.03
TOMAHAWK	1	0.3957	0.002
SRAM II	0	1.84	-0.043
MINUTEMAN2	1	1	-0.02
TRIDENT 2	1	1.1391	0.028
ICBM	0	*	0.032
ALCM	0	3.3137	0.002
SRAM	0	0.5841	0.014
MINUTEMAN3	1	1	0.014
CONDOR	0	53	0.014
MAVERICK A	0	*	0.01

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